

# The atmospheric response to SST forcing within the North Pacific western boundary current

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Collaborators: Young-Oh Kwon, Claude Frankignoul

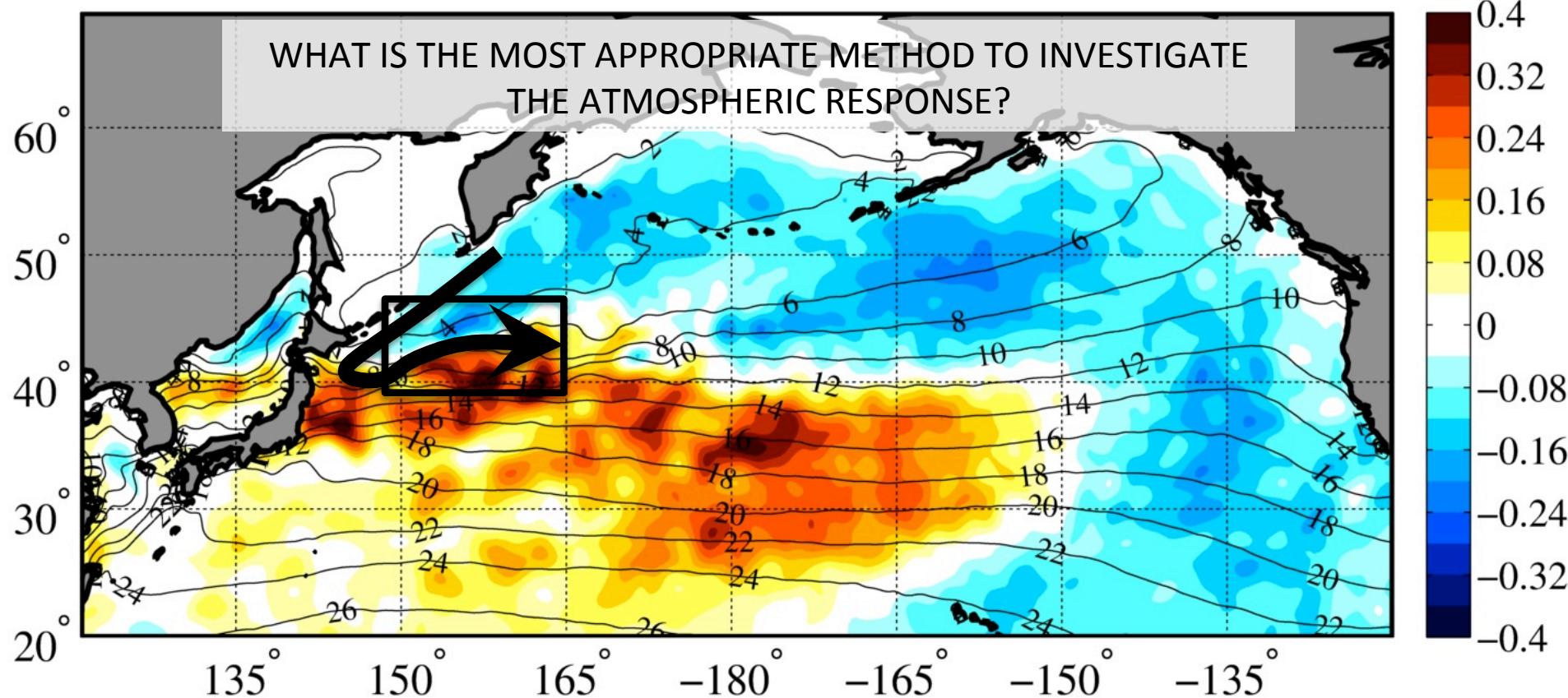
Climate Change/Variability Working Group Meeting  
3.4.2013

# Outline

- Overview of Oyashio Extension (OE) variability
  - Justification of prescribed SST experiments
- Modeling OE variability with CAM5
  - Local response
  - Remote response
- Conclusions

# The Oyashio Current

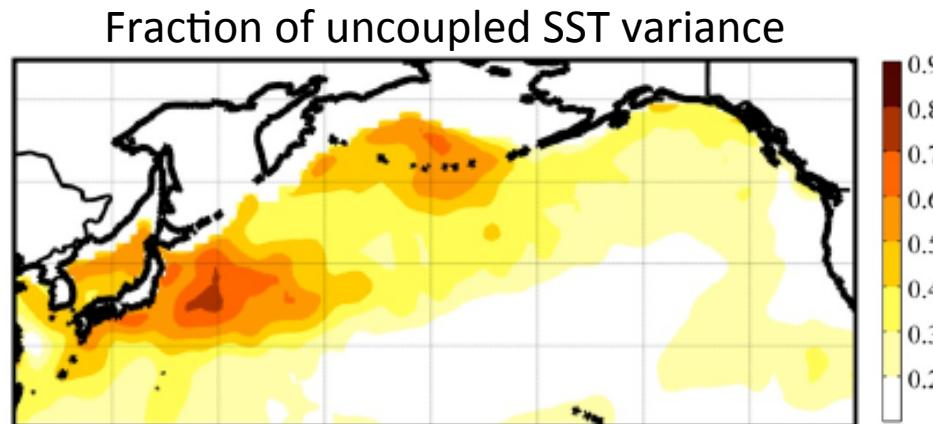
SST Regressed on Oyashio Extension Index



# Prescribing SST anomalies

- Extratropical SSTs are largely *forced* by the atmosphere
- However, western boundary currents contain internal oceanic dynamics capable of generating SST anomalies
- Extend Barsugli and Battisti (1998) coupled model, but *empirically*:

$$\frac{d}{dt} \begin{bmatrix} T_A \\ T_S \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} T_A \\ T_S \end{bmatrix} + \begin{bmatrix} \xi_A \\ \xi_S \end{bmatrix} \quad \begin{aligned} b : T_S &\rightarrow T_A \\ c : T_A &\rightarrow T_S \end{aligned}$$



Smirnov, D., M. Newman and M. Alexander, 2013: Investigating the role of ocean-atmosphere coupling in the North Pacific Ocean. *J. Climate*, submitted.

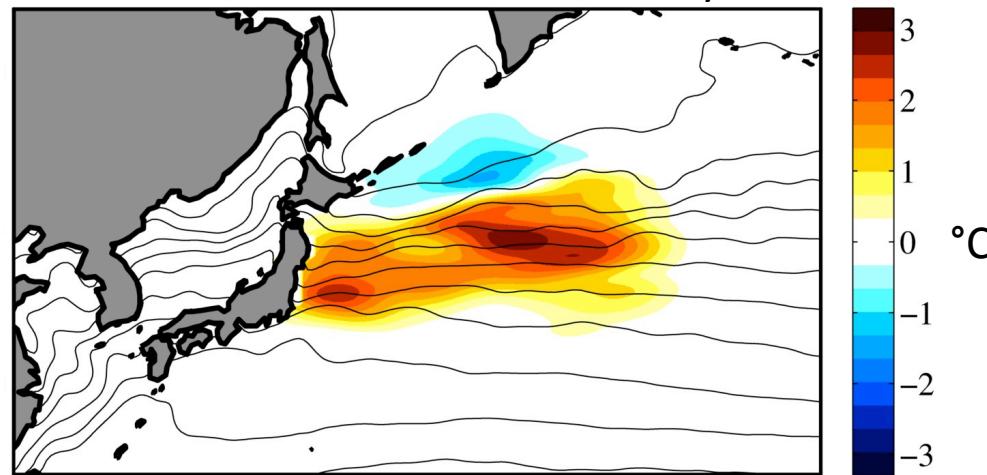
# Oyashio front strength

Northward Front Shift

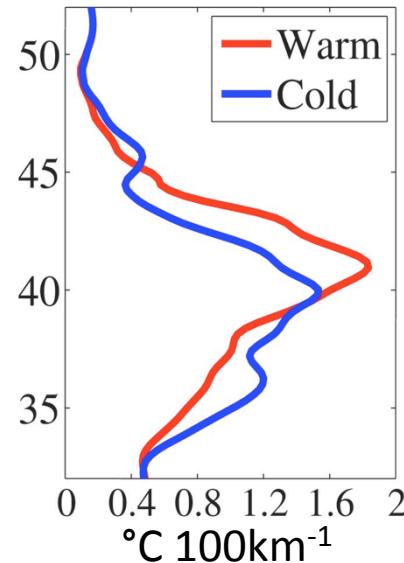


**WARM**

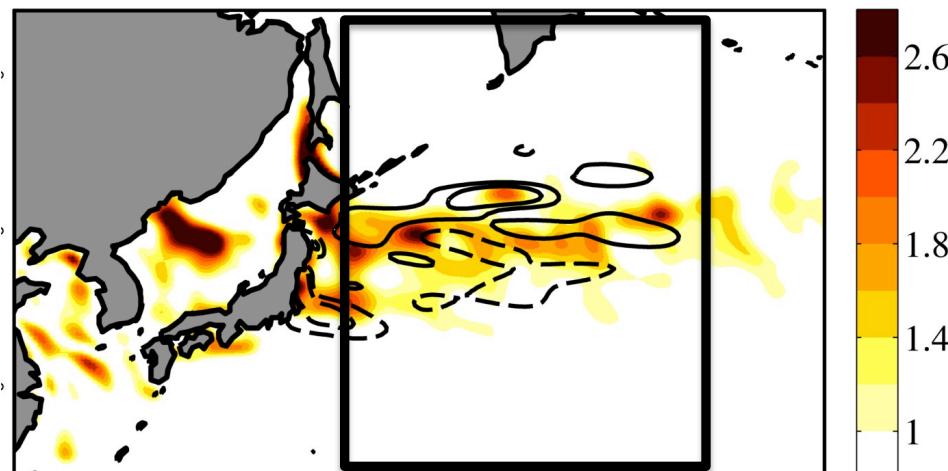
Mean NDJFM SST and anomaly



Zonal mean  $\nabla$ SST



Mean  $\nabla$ SST and anomaly



# Experimental design

## 0.25° CAM5

- Finite volume dynamical core
- Hybrid P/ $\sigma$  vertical coordinate with 30 levels
  - 8 levels within boundary layer (1000-800 mb)
- Prescribed sea-ice and SST (0.25° NOAA-OI), fully coupled land experiments
- Initialize 25 warm and cold ensembles with SST anomaly on Nov 1 (**warm** → northward/stronger Oyashio SST front)
- Initial land condition does not vary
- Simulations run through Dec 31

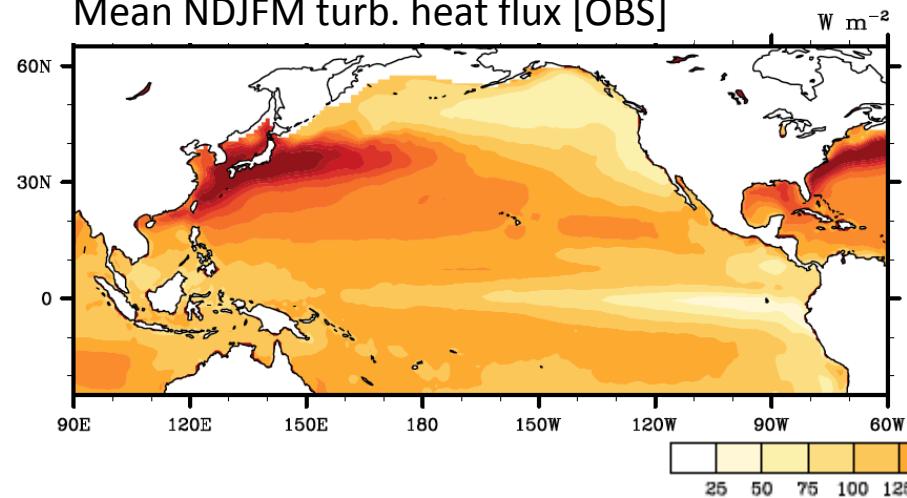
# 0.25° CAM5 Control climate\*

\*Simulation was run by M. Wehner (LBNL)

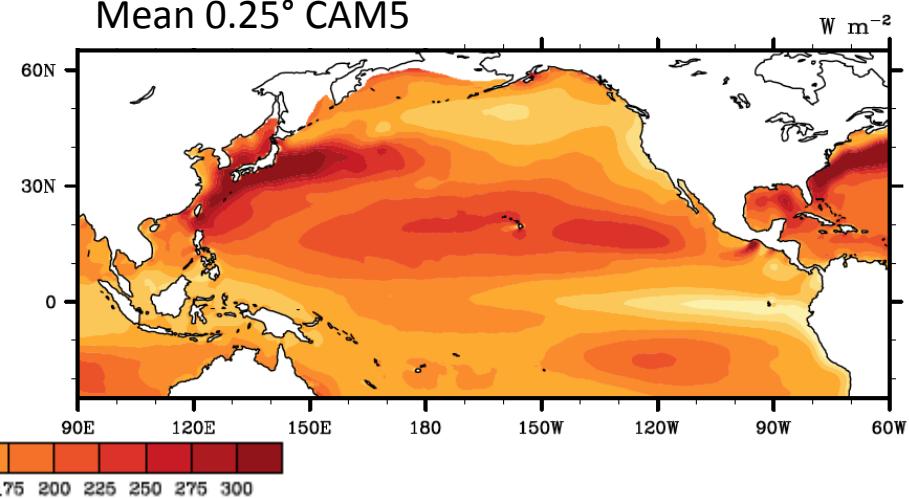
# CAM5 Control: Heat flux

→ 0.25° CAM5 control forced by *observed* SST from 1980-2006.

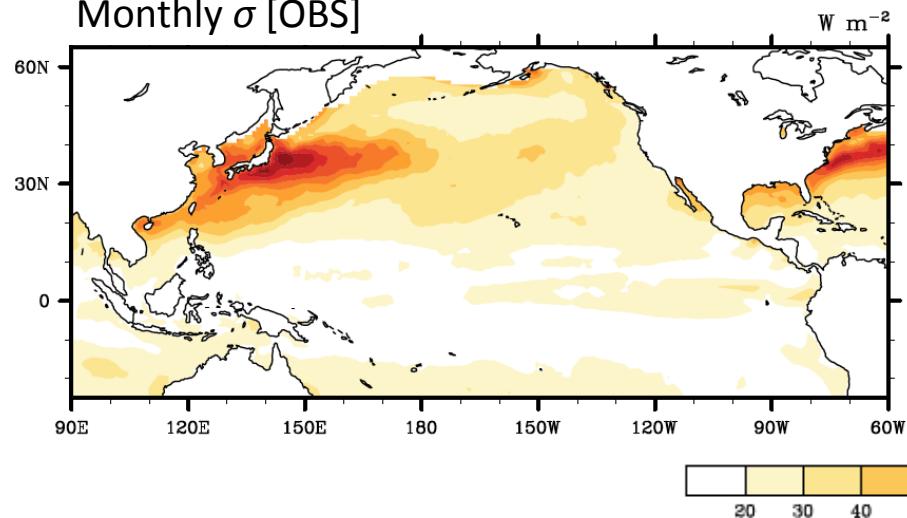
Mean NDJFM turb. heat flux [OBS]



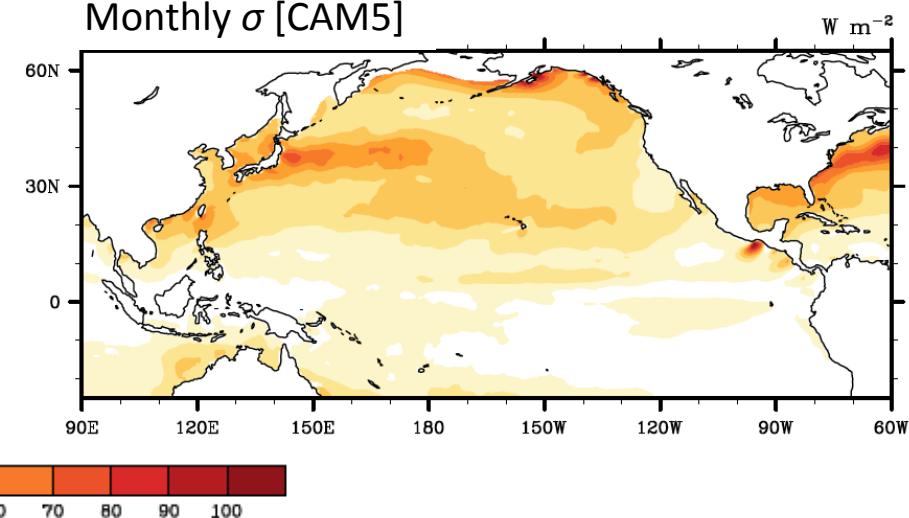
Mean 0.25° CAM5



Monthly  $\sigma$  [OBS]

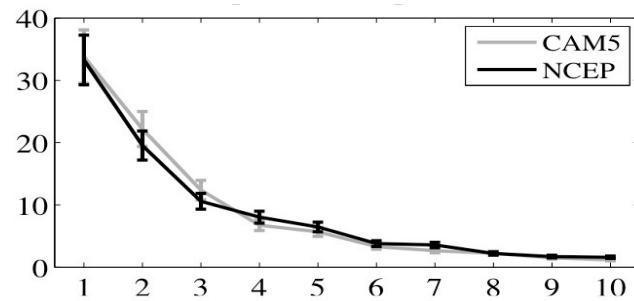


Monthly  $\sigma$  [CAM5]

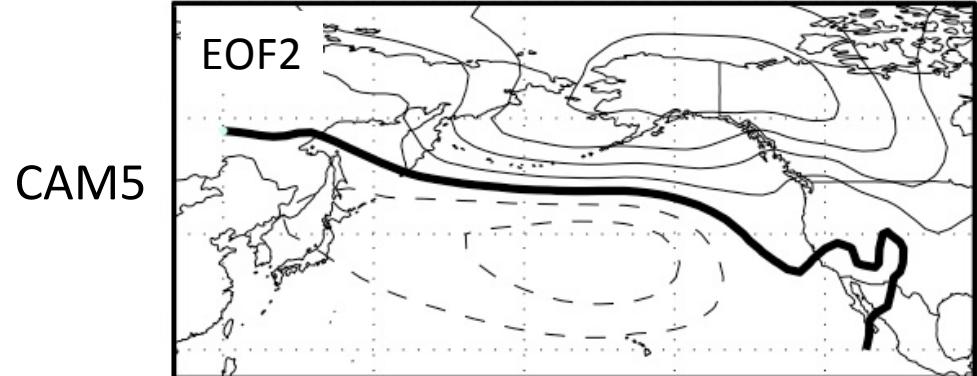
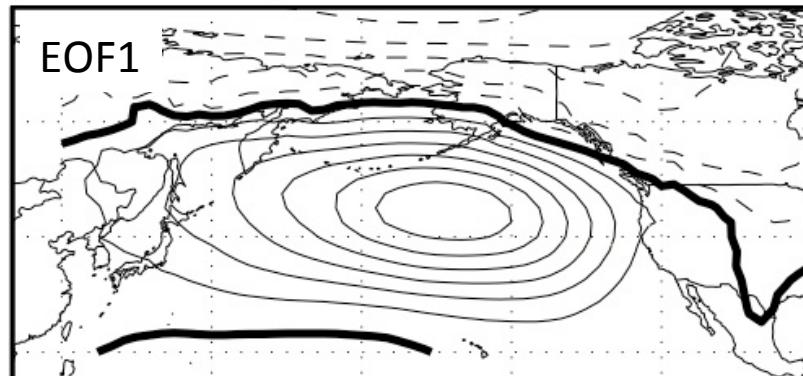
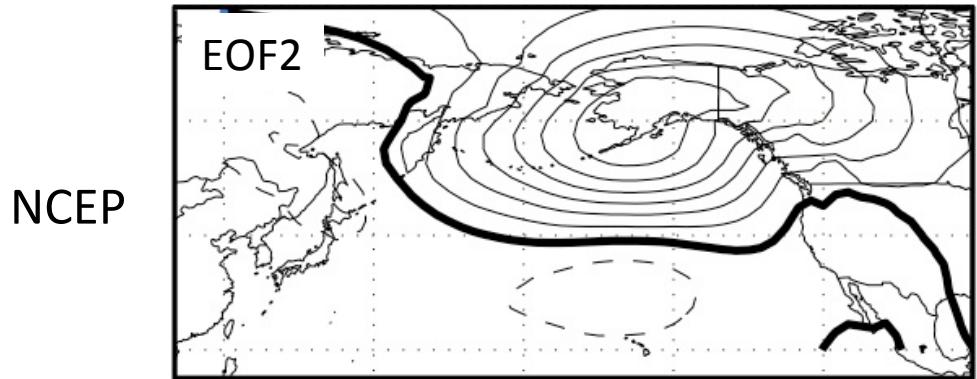
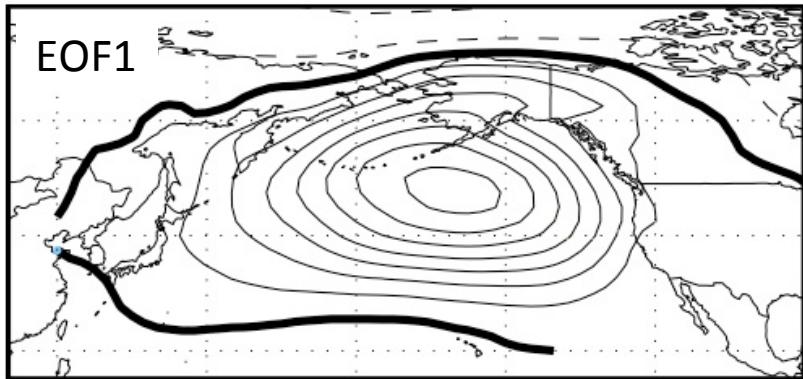


# CAM5 Control: SLP Variability

Pacific Decadal  
Oscillation



North Pacific  
Oscillation

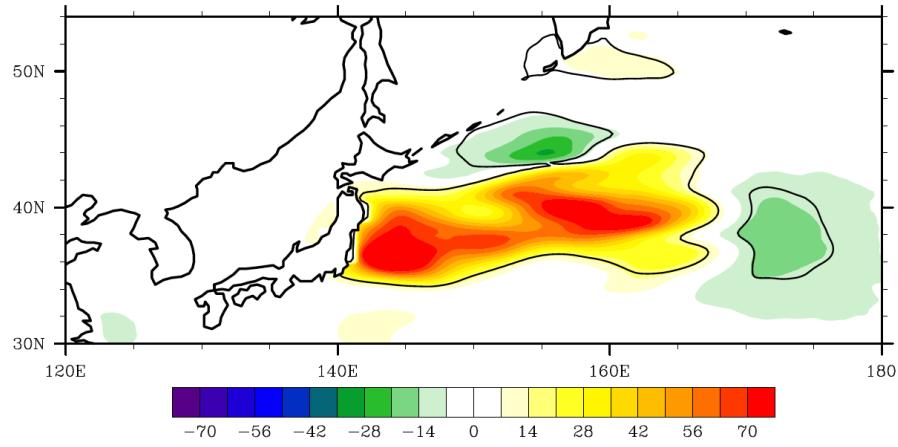


# Oyashio Front experiment: LOCAL RESPONSE

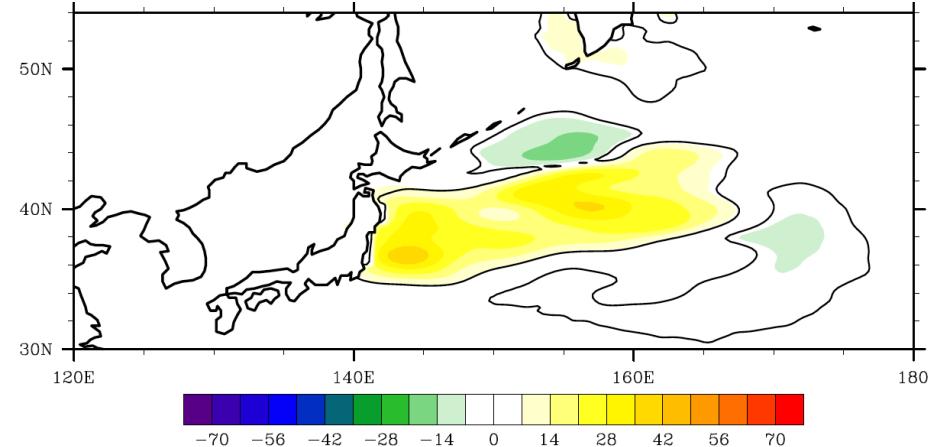
# Local response: energy budget

$$\Delta NHF = \Delta SW + \Delta SH + \Delta LH + \Delta LW$$

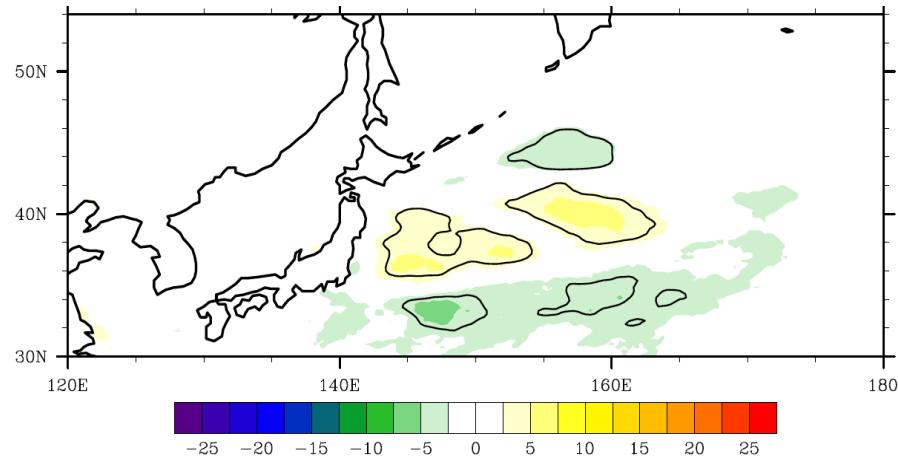
$\Delta LH$  Flux



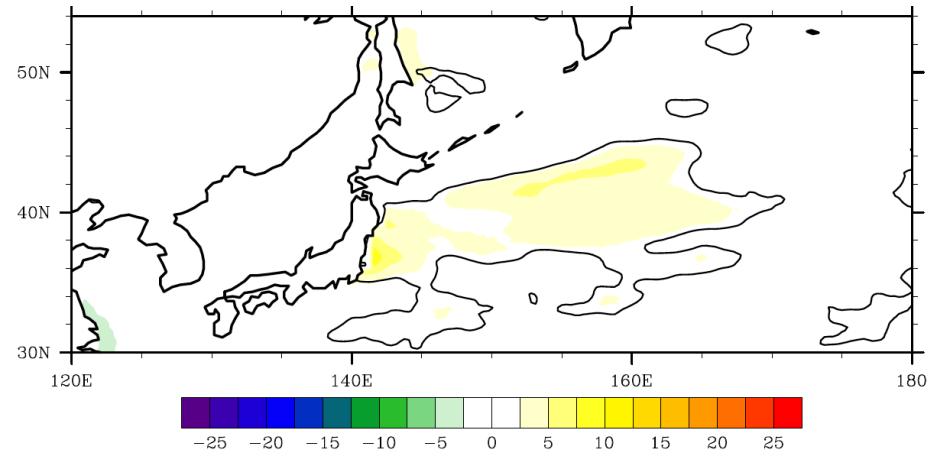
$\Delta SH$  Flux



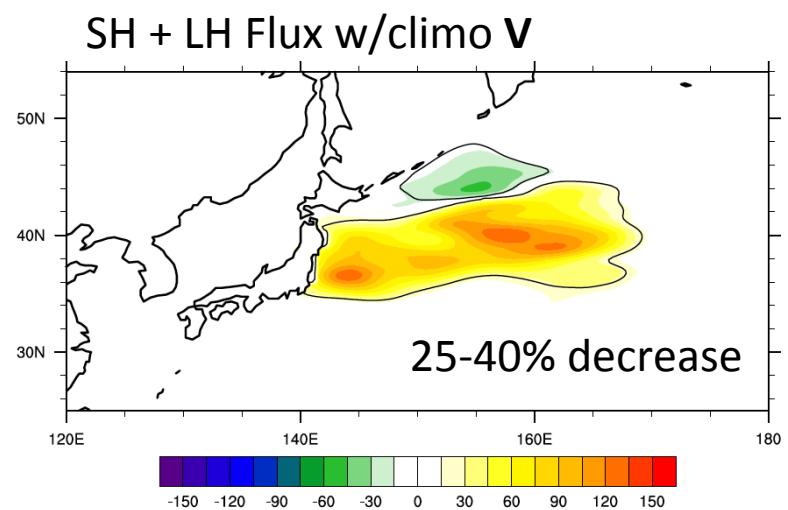
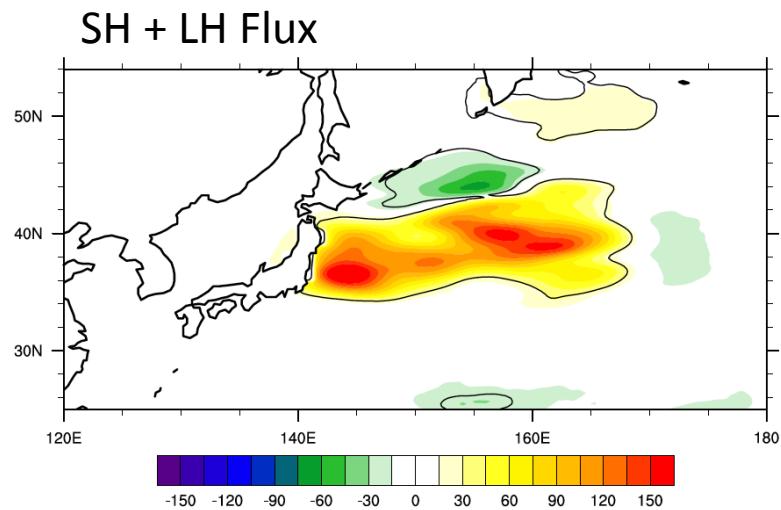
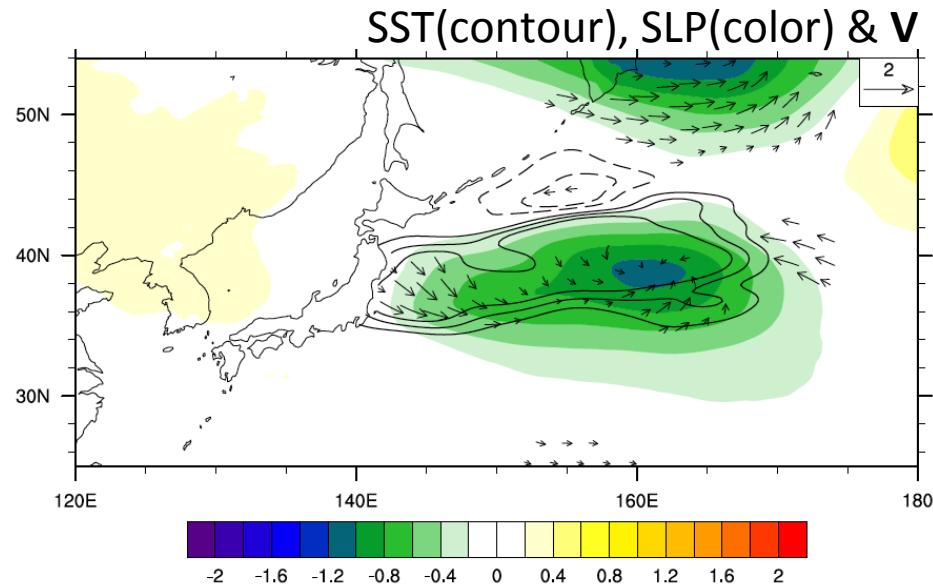
$\Delta SW$  Flux



$\Delta LW$  Flux

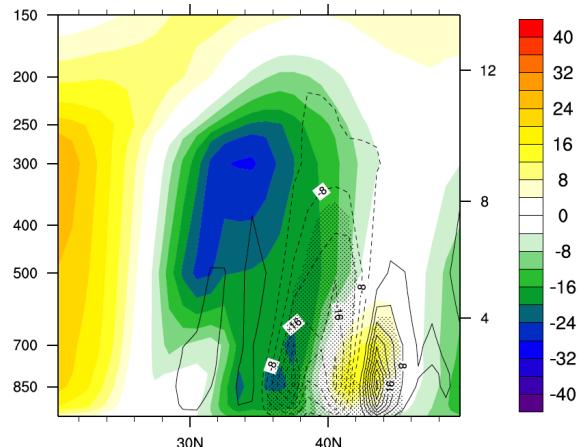
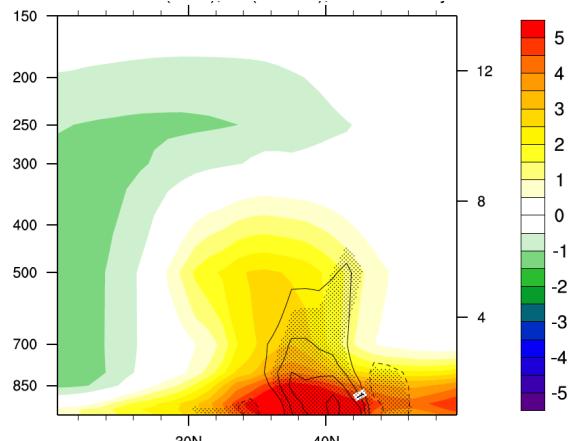
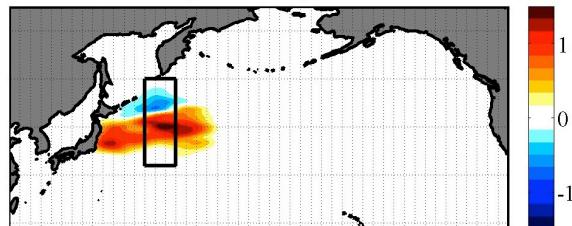


# Local response: wind feedback

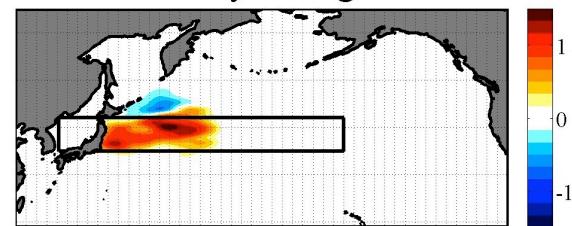


# Local response: vertical depth

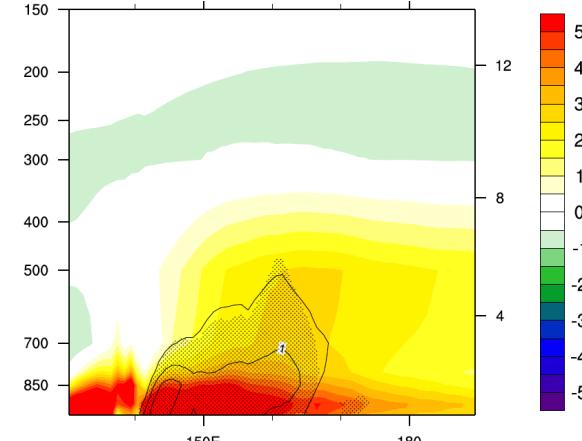
Zonally averaged area



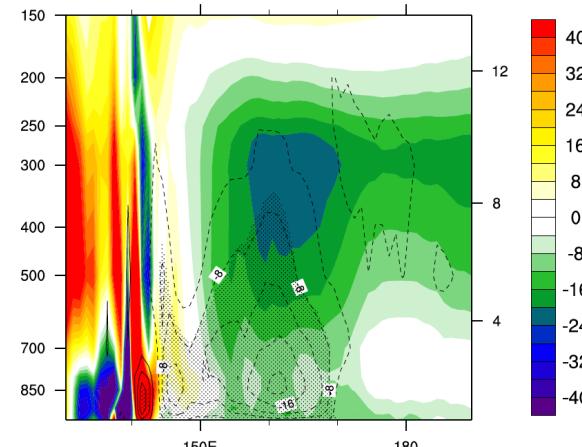
Meridionally averaged area



Total diabatic  
heating  
[K day<sup>-1</sup>]



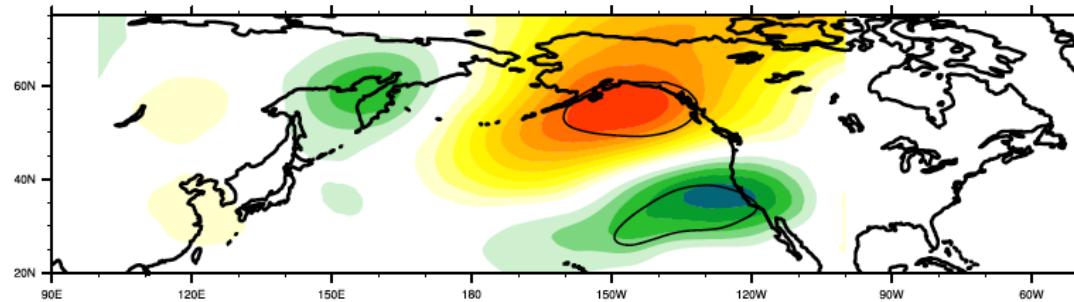
Omega  
[mb day<sup>-1</sup>]



# REMOTE RESPONSE

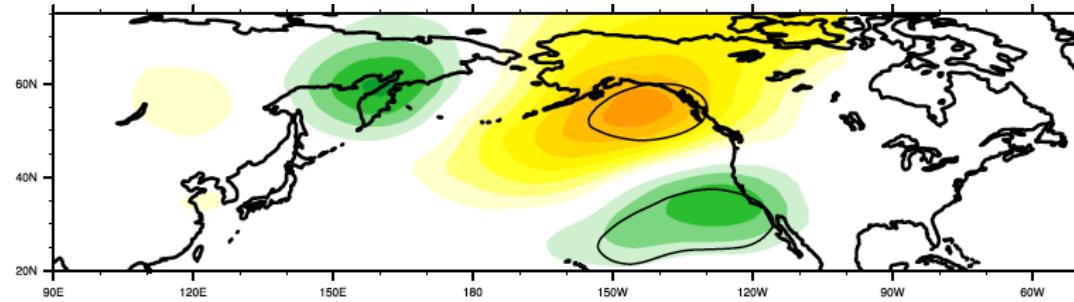
# Remote response: mean circulation

250mb



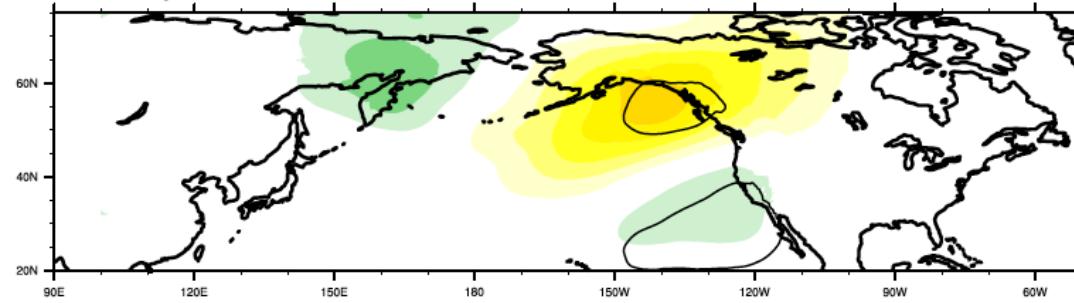
50m  
-50m

500mb



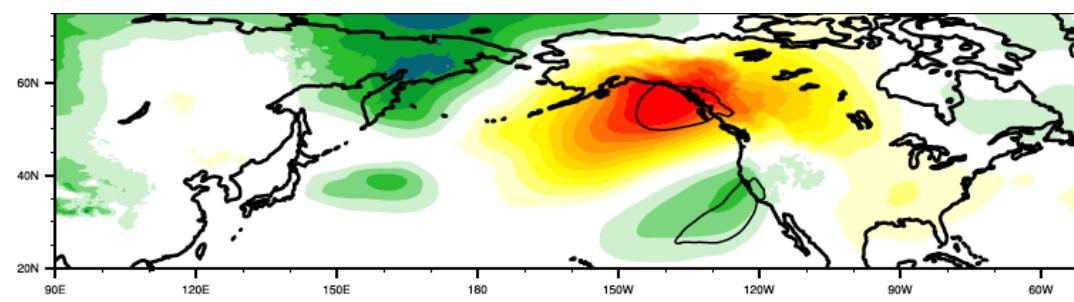
50m  
-50m

850mb



50m  
-50m

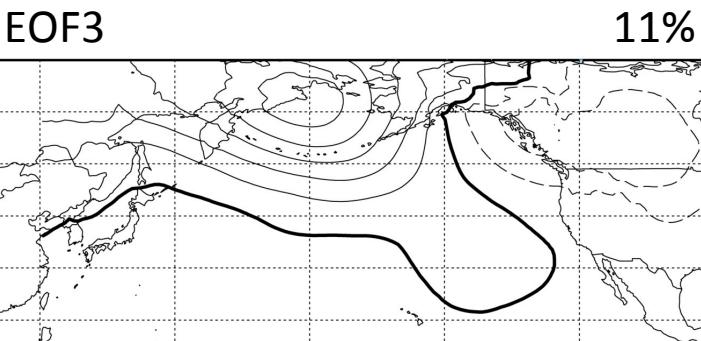
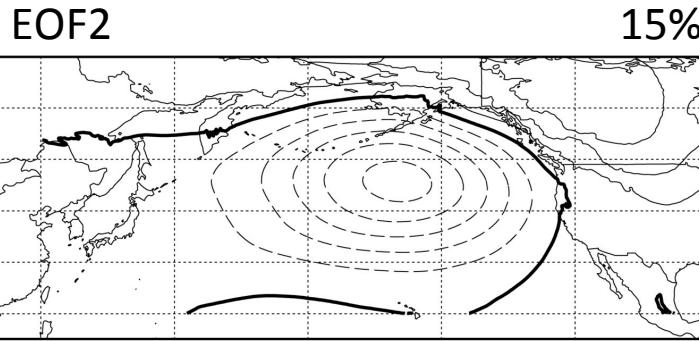
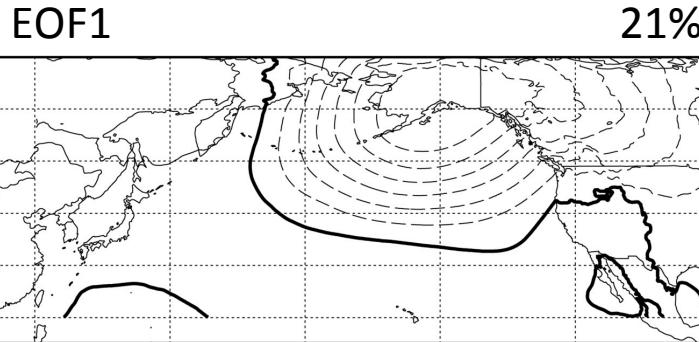
SLP



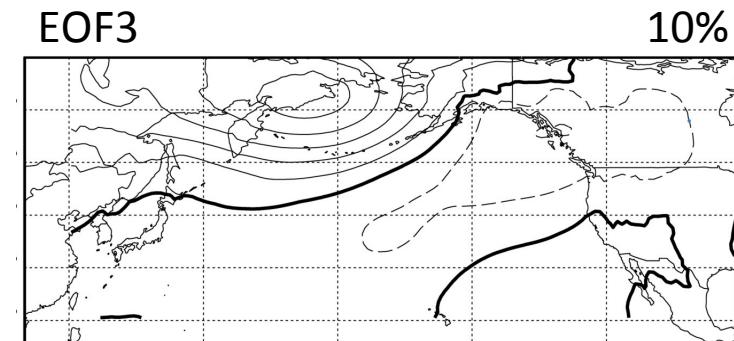
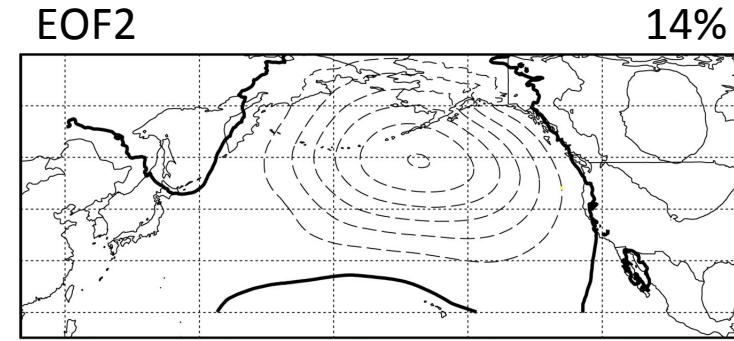
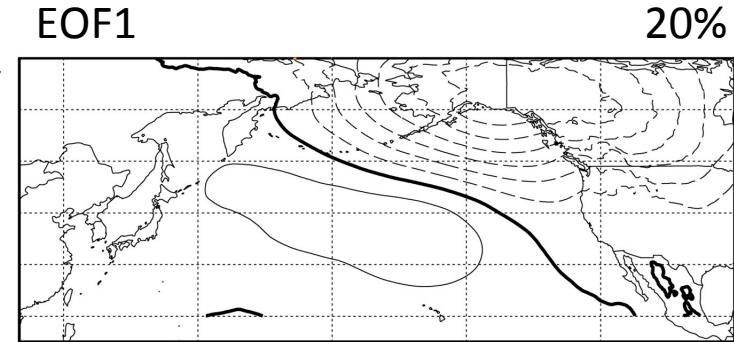
3mb  
-3mb

# Remote response: SLP variability

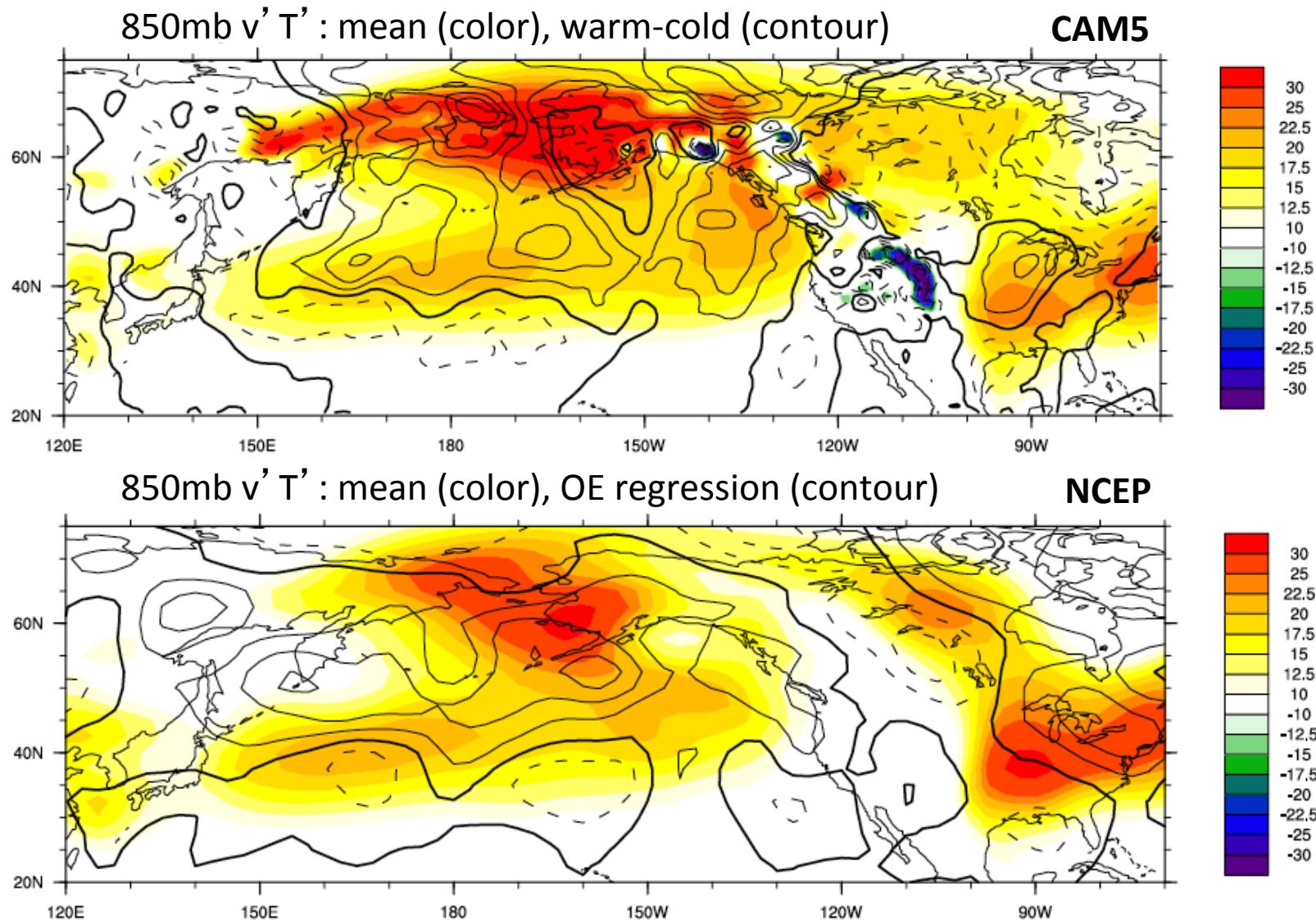
WARM



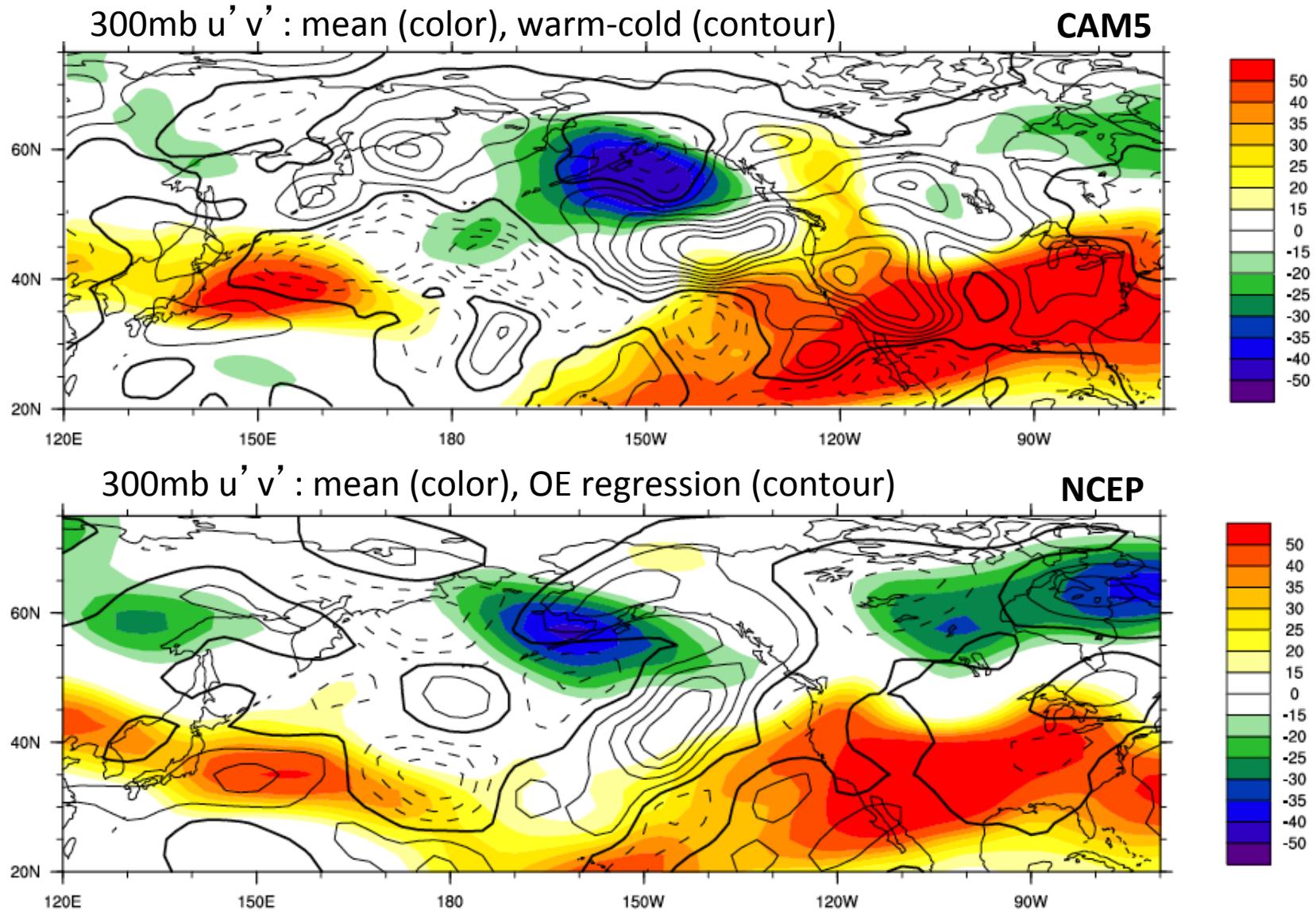
COLD



# Remote response: transient HF

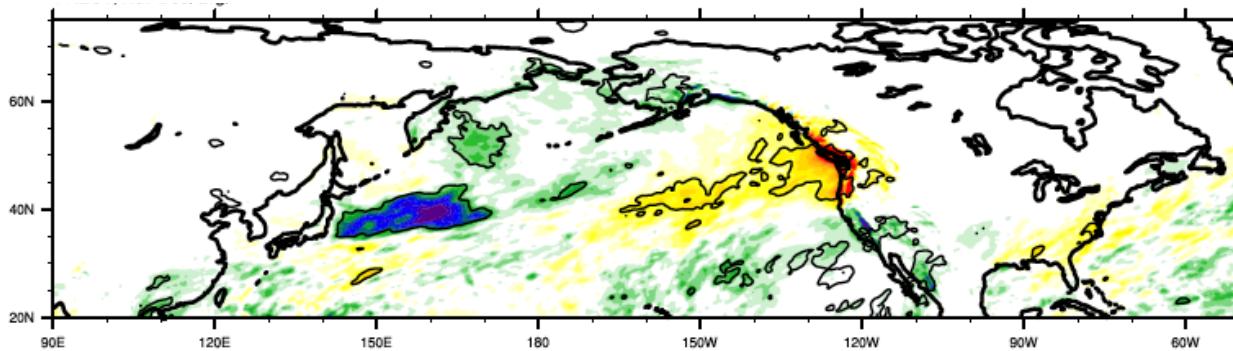


# Remote response: momentum flux

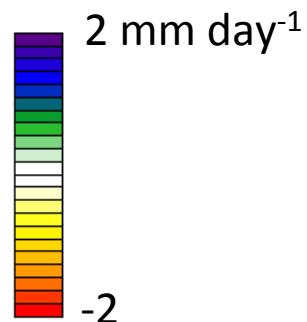
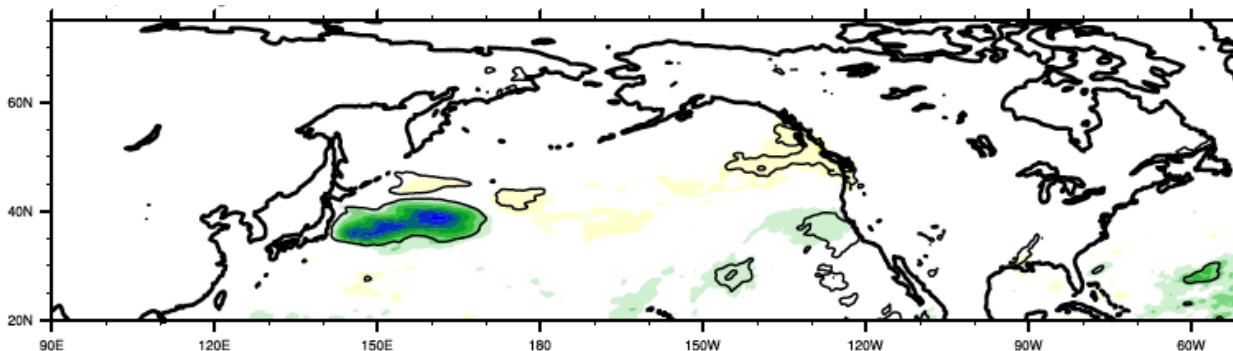


# Remote response: sensible impact

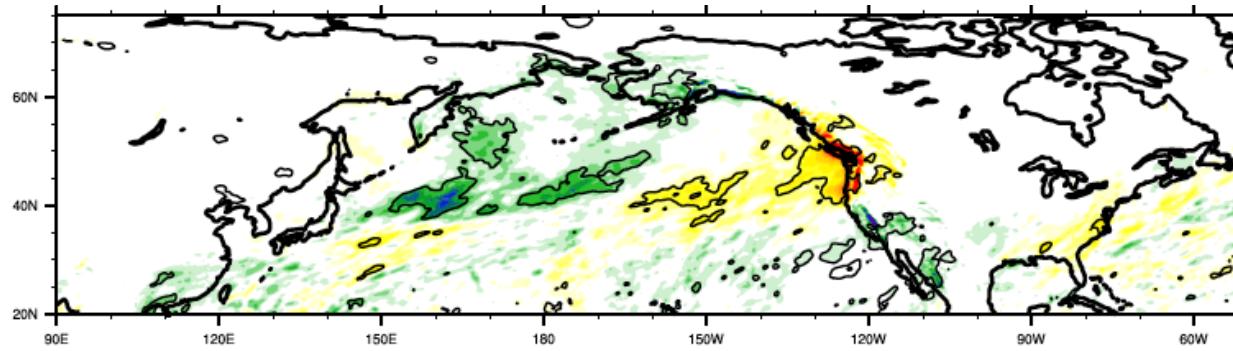
TOTAL  
PRECIP



CONVECTIVE



STRATIFORM

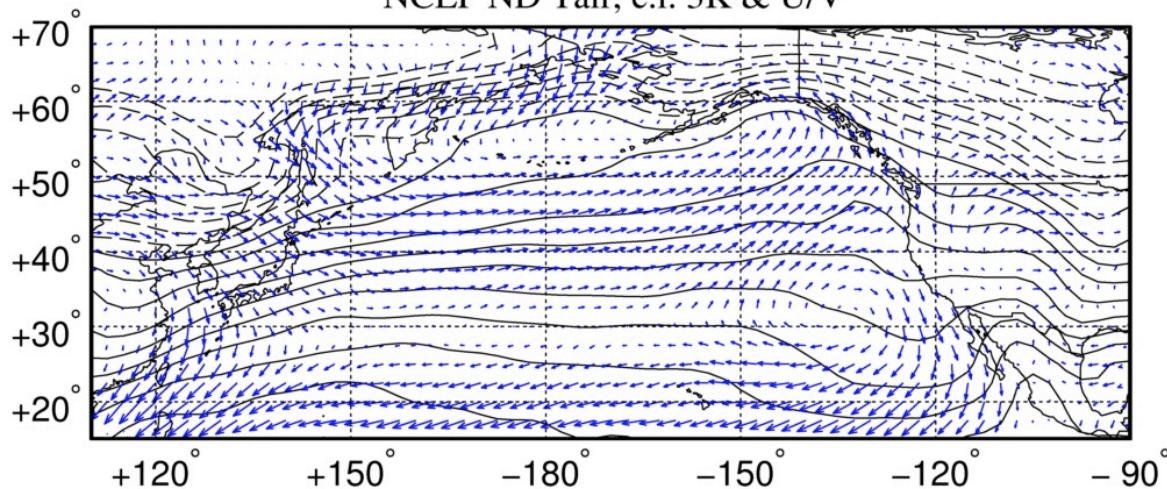


# Conclusions

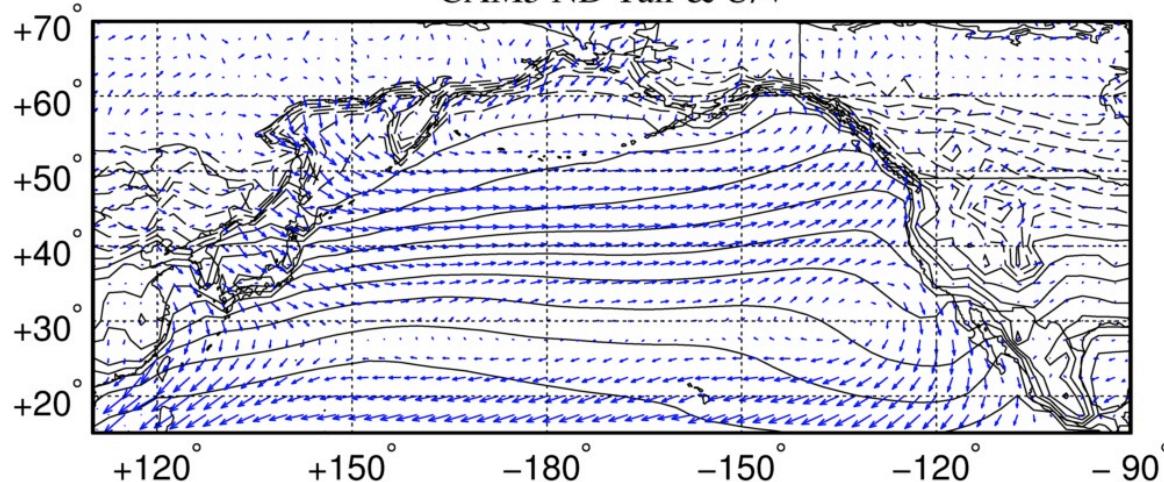
- The impact of the Oyashio SST front on the atmosphere can be modeled by prescribing SST anomalies
- The *local* response is characterized by a large change in turbulent fluxes, altering the atmospheric circulation to ~400mb
- The *local* dynamical response amplifies heat flux anomalies by 25-40%
- The *remote* response alters the mean strength of the Aleutian low and the structure of the dominant modes of SLP variability
- Sensible impacts include large changes in precipitation along the west coast of North America

# Miscellaneous

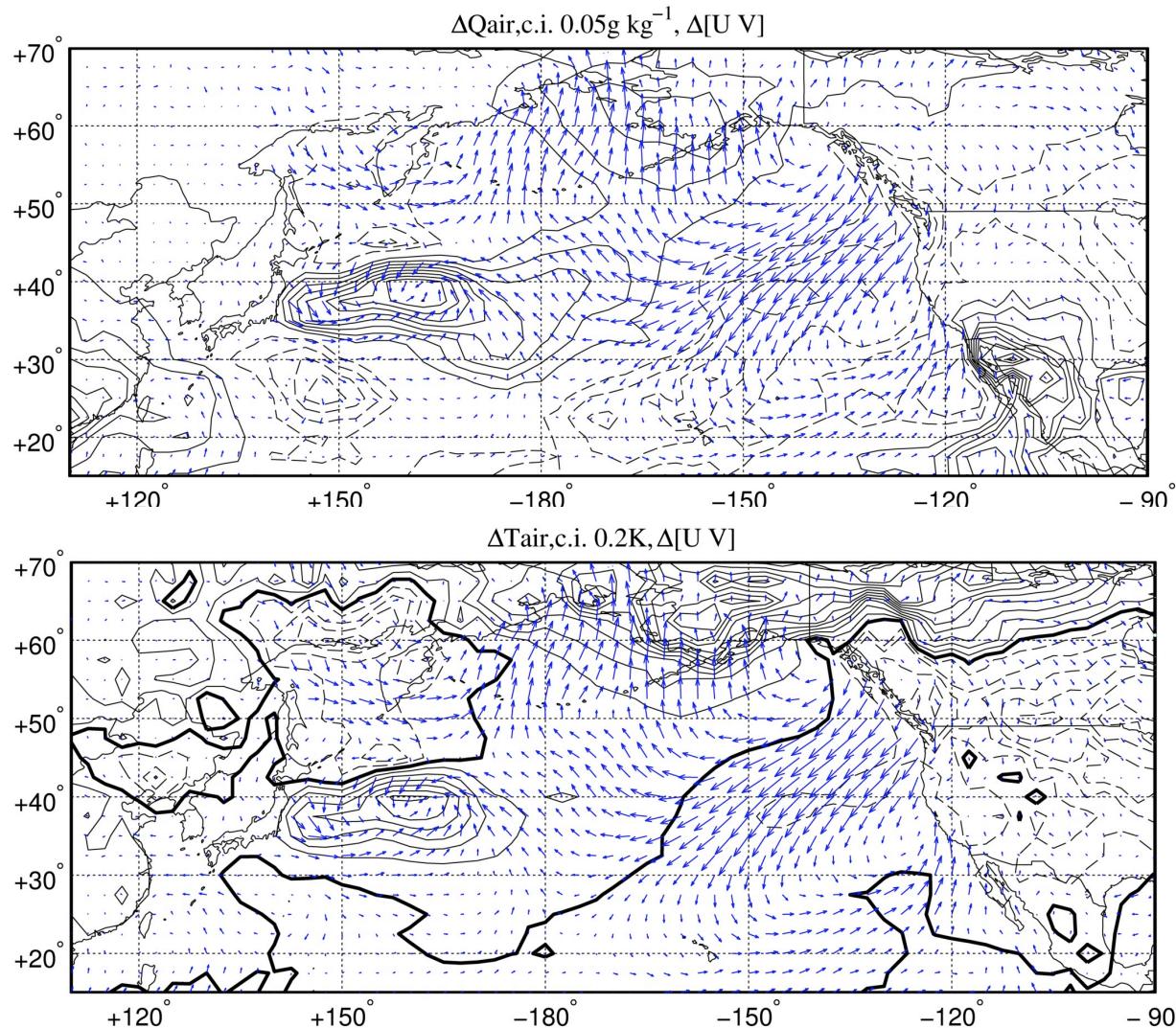
NCEP ND Tair, c.i. 3K & U/V



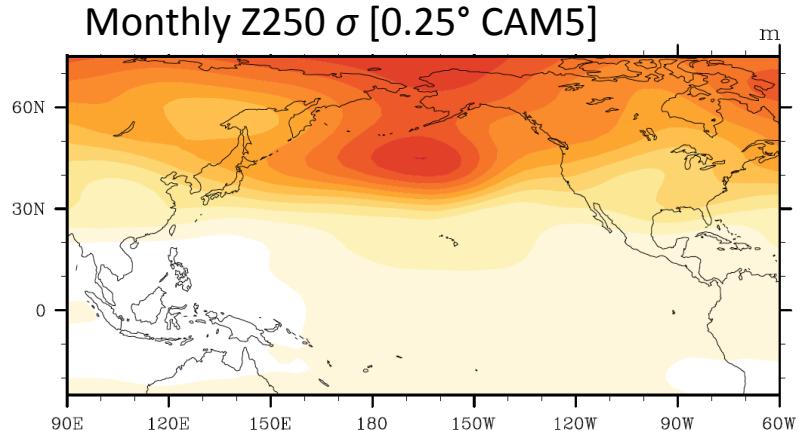
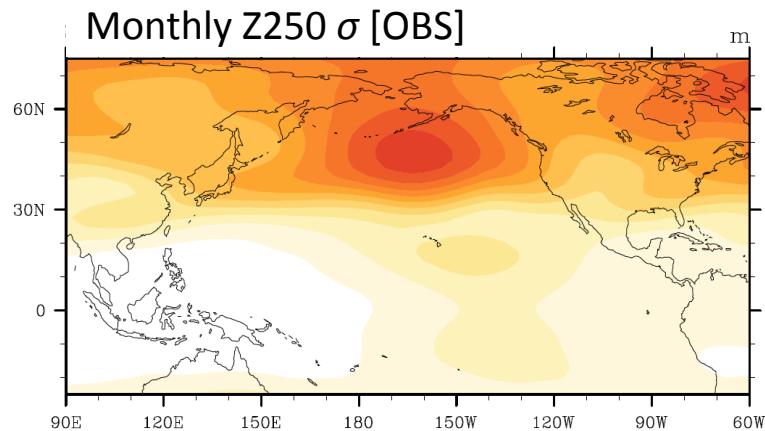
CAM5 ND Tair & U/V



# Miscellaneous



# CAM5 Control: 250Z Variability



# CAM5 Control: 250Z Variability

